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Canal Development and Intensification of Rice Cultivation in the Mekong Delta: A Case Study in Cantho Province, Vietnam

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Abstract

The present study described the development process of water management and rice cultivation at a village in the Mekong Delta in the three periods, before the unification of Vietnam in 1975, the socialist economy period and the *doi moi* period. The interdependencies between canal development and intensification of rice cultivation and between agricultural development and institutional setting are found to be driving factors in agricultural development as well as social changes.

I Introduction

The present paper highlights the process of canal development and intensification of rice cultivation in the Vietnamese part of the Mekong Delta during the second half of the 20th century, particularly after the unification of Vietnam in 1975. This process is of particular interest in two points.

The first point is the interdependency between improvement of infrastructure and innovation of cultivation techniques in agricultural development. These two factors are mutually indispensable for agricultural development. Infrastructure improvement provides better production environment in terms of water and soil, and technical innovation in such areas as variety selection, fertility control and crop care upgrades production methods to fit the improved environment. Infrastructure improvement without changes in cultivation techniques can not bring a satisfactory return on the investment, and technical innovation without infrastructure improvement has only limited effect in increasing agricultural productivity.

The tropical monsoon deltas of Southeast Asia are inundated for half of the year and dry for the remaining half. This hydrological environment is suitable for extensive rice cultivation, and the deltas have long been used in part for rice cultivation. However, the environment hindered intensification of rice cultivation and diversification of cropping due to the excessive depth of water in the rainy season and the lack of water in the dry season. Moderating the hydrological environment by infrastructure improvement is

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essential for agricultural intensification and diversification in the deltas. At the same time, water conditions cannot be perfectly controlled, and adaptation to the given semi-controlled water conditions by innovation and proper selection of cultivation techniques also plays a crucial role in agricultural development. This interdependency between infrastructure development and technical innovation should also be observable in the process of agricultural development in the Mekong Delta during the study period.

The second point of interest is the impact of institutional changes on agricultural development. In the second half of the 1960s and the first half of the 1970s, a "land to the tiller" policy and land reform were implemented by the government of South Vietnam at that time with strong support of the United States [Callison 1983]. After the unification of Vietnam in 1975, the political and economic systems changed completely. The market economy was replaced by a socialist economy, individual land ownership was abolished, and agriculture was collectivized at the village and hamlet levels, though the period of collectivized farming was much shorter in the Mekong Delta than in the northern part of the country. Since the introduction of the *doi moi* policy in the mid-1980s, the market economy has gradually been recovering, and agricultural households are acquiring land use rights. These drastic changes in the political and economic systems should have substantially affected the process of agricultural development of the delta in terms of both infrastructure improvement and technical innovation.

The present study is based on a case study conducted at a village in Cantho province in the Mekong Delta. Field surveys were carried out on two occasions between 1996 and 1998.

II The Mekong Delta

II－1 *Hydrological Setting and Canal Development*

From its apex at Kongpong Cham in Cambodia, the Mekong Delta covers an area of 5.9 million ha, of which about 3.9 million ha is in Vietnam [Nguyen Van Sanh *et al.* 1998]. Nguyen Huu Chiem [1994] divided the Vietnamese part of the Mekong Delta into four land units from the viewpoint of landform: the upper floodplain or high floodplain, the tide-affected floodplain, the coastal complex, and the broad depression. Tanaka [1995] added the plain of reeds as an independent land unit because of its particular soil and water environment and rice culture. I propose to add one more land unit, the Long Xuyen quadrangle, which occupies the northwestern part of the delta, on the opposite side of the Hau and Tien rivers from the plain of reeds. This area is characterized by flat lowland and acid sulfate soil, and has a hydrological environment of deep inundation in the rainy season and desiccation in the dry season, which is similar to the plain of reeds and different from the floodplain. In this way, the delta is divided into six land units (Fig. 1).

The hydrological systems of the upper floodplain and tide-affected floodplain are

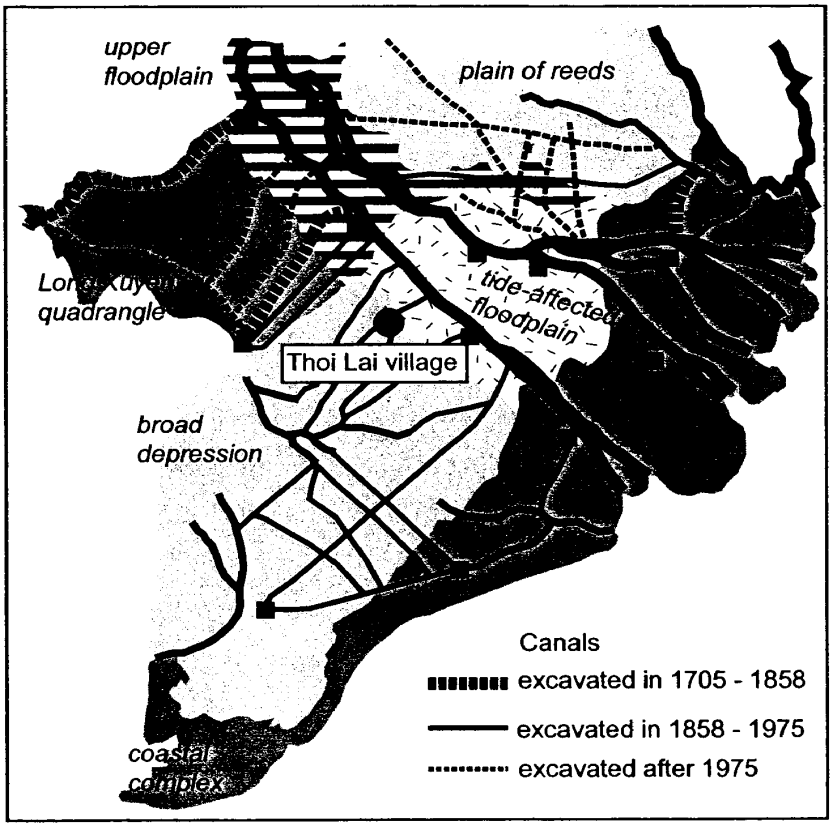

Fig. 1　Canal Layout in the Mekong Delta

Sources: Prepared based on Nguyen Huu Chiem [1995], Tanaka [1995] and Nguyen Van Sanh *et al.* [1998].

governed by the Hau and Tien rivers through natural streams and small-scale canals. The river water level fluctuates according to tidal movements throughout the year except for the high flood period (Fig. 2). This results in a year-round supply of fresh surface water in these areas. The river-made micro-topography is also well developed, and natural levees are not inundated even in the flood season.

The hydrological system of coastal complex is governed by the sea, and a sea-made micro-topography of sand ridges and inter-ridges has developed. Though sea water intrudes into inter-ridges in the dry season, fresh groundwater is available throughout the year in the sand ridges. The sea also governs the hydrological system of the broad depression through natural streams, but its influence is weaker here than in the coastal complex and the micro-topography is faint. The hydrological environment of this area is spatially monotonous. The land is covered with deep rainwater in the rainy season due to poor drainage, and canal water is brackish in the dry season.

The plain of reeds and the Long Xuyen quadrangle were originally separated from the rivers and the sea, and had an independent hydrological system. Inundation began with the start of the rainy season in April or May and reached the maximum depth at the

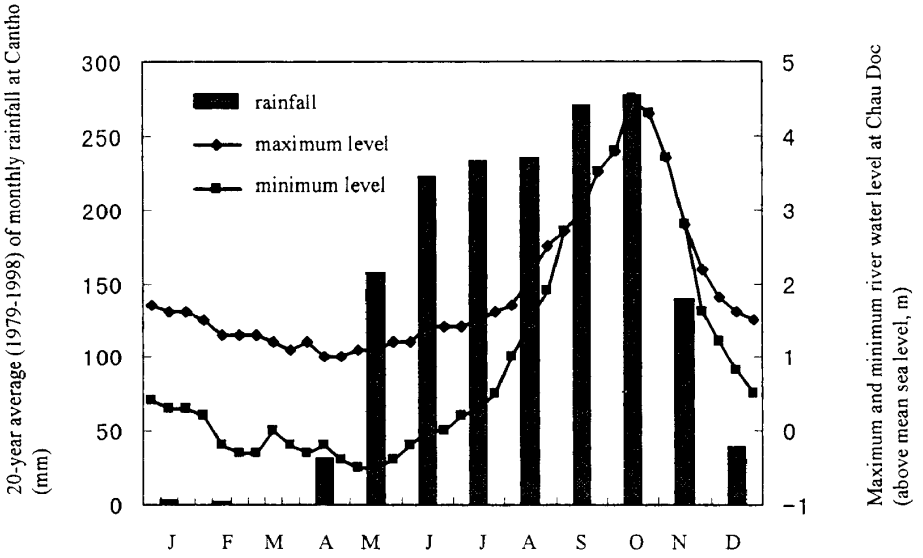

Fig. 2 Seasonal Changes in Rainfall and River Water Level

Sources: Prepared based on Hori [1996] and data obtained from the Meteorological Department.

end of the rainy season. After rain stopped and the dry season started, the water level fell, and finally these areas dried up completely.

These differences in hydrological environment are clearly reflected in the progress of human settlement. Human settlement in the Mekong Delta is thought to have started in the tide-affected floodplain, then spread into the upper floodplain and the coastal complex. In these areas, freshwater resources could be easily accessed by means of small-scale canals and shallow wells. These limited resources provided sufficient water for domestic use and even for dry-season cropping of fruits and vegetables. Spontaneous migrants, however, could not settle in other areas due to lack of fresh water in the dry season, excessive inundation in the rainy season and lack of transportation.

Many large-scale canals were excavated particularly in the broad depression during the French period and in the plain of reeds and the Long Xuyen quadrangle after the unification in 1975 (Fig. 1). One of the primary purposes of canal excavation was to facilitate transportation between local towns and Ho Chi Minh city. The other purpose was land reclamation. These canals provided new settlers with lands for housing and a means of transportation. The hydrological environment was also improved and became more suitable for rice cultivation, because fresh water from the rivers reached deeper into these areas.

II－2 *Changes in Rice Production*

The Mekong Delta produced surplus rice for export until the beginning of the 1960s. Then rice production stagnated and South Vietnam even began to import rice [Vo Tong Xuan 1975]. Even after the war ended and the country was unified, rice production did not recover for many years. Then, in 1989, Vietnam suddenly resumed exporting rice, and

by 1996 it had become the world's second biggest rice exporter. This rice was mostly produced in the Mekong Delta.

Previous research and statistical data show that high-yielding varieties (HYVs) were introduced into Vietnam from the International Rice Research Institute in 1968. The yielding ability of HYVs was 1.5 to 2 times higher than that of local varieties. HYVs also allowed double-cropping because of their shorter growing period. HYVs spread rapidly into the tide-affected floodplain, where they occupied about the half of the total cultivated area by 1973. In the other areas, however, cultivation of HYVs was limited to 10 to 20% of the total cultivated area due to inadequate soil and water conditions [*ibid.*]

After 1975, canal excavation in the plain of reeds and the Long Xuyen quadrangle promoted the expansion of paddy land. In the decade from 1985 to 1995, paddy area increased by 26% in Long An province, where the plain of reeds is located, and 16% in Kien Giang province, where the Long Xuyen quadrangle is located [General Statistical Office 1996]. Cropping patterns have also changed. Single cropping of local varieties has been rapidly replaced by double cropping of HYVs since the second half of the 1980s (Table 1).

This information indicates that the government and farmers have tried to achieve area expansion, cropping multiplication and yield increase during the last three decades. Their trials were generally not fruitful in the first two decades and quite successful in the last decade, resulting in production of a substantial surplus of rice and its export. It is, however, thought that development patterns of agriculture vary widely according to land and economic conditions at the district, village and hamlet levels. The process by which infrastructure improvement and technical innovation expanded cultivated area, multiplied cropping system and increased yields will be clarified in the following case study.

Table 1 Changes in Cropping Patterns and Yields of Rice in the Mekong River Delta

Period	Cropping Pattern (%)				Rice Yield (t/ha)		
	single cropping of local varieties	single cropping of high-yielding varieties	double cropping of high-yielding varieties	triple cropping of high-yielding varieties	local varieties	high-yielding varieties	average
1976–80	75	7	19	0	1.91	2.42	2.09
1981–85	74	6	20	0	2.30	3.46	2.76
1986–90	59	4	35	1	2.55	3.92	3.32
1991–95	43	4	50	3	2.96	4.16	3.82

Sources: Estimated from General Statistical Office [1991; 1996]

III Thoi Lai Village

Thoi Lai village, O Mon district, Cantho province was selected for the present study. Thoi Lai village is located at the junction of four watercourses, the O Mon river, the Dung canal, the Thi Doi canal and the O Mon canal (Fig. 3). The junction is about 12 km far from O Mon town, which is located on the right bank of the Hau river. The land between O Mon town and the junction is part of the tide-affected floodplain, and the western part of the village is in the broad depression. A motorable road running between O Mon town and the center of the village, located near the junction of the water courses, was paved in 1993, but the major mode of transportation in the village is by boat.

The total population of the village was about 30,000 in 1997. There were 5,485 households, of which 95% were rice cultivators. The remaining 5% were engaged in miscellaneous occupations such as trading, cottage industry and agricultural labor. The village has 14 hamlets, of which the eastern 5 hamlets, Thoi Binh, Thoi Loc, Thoi Hoa,

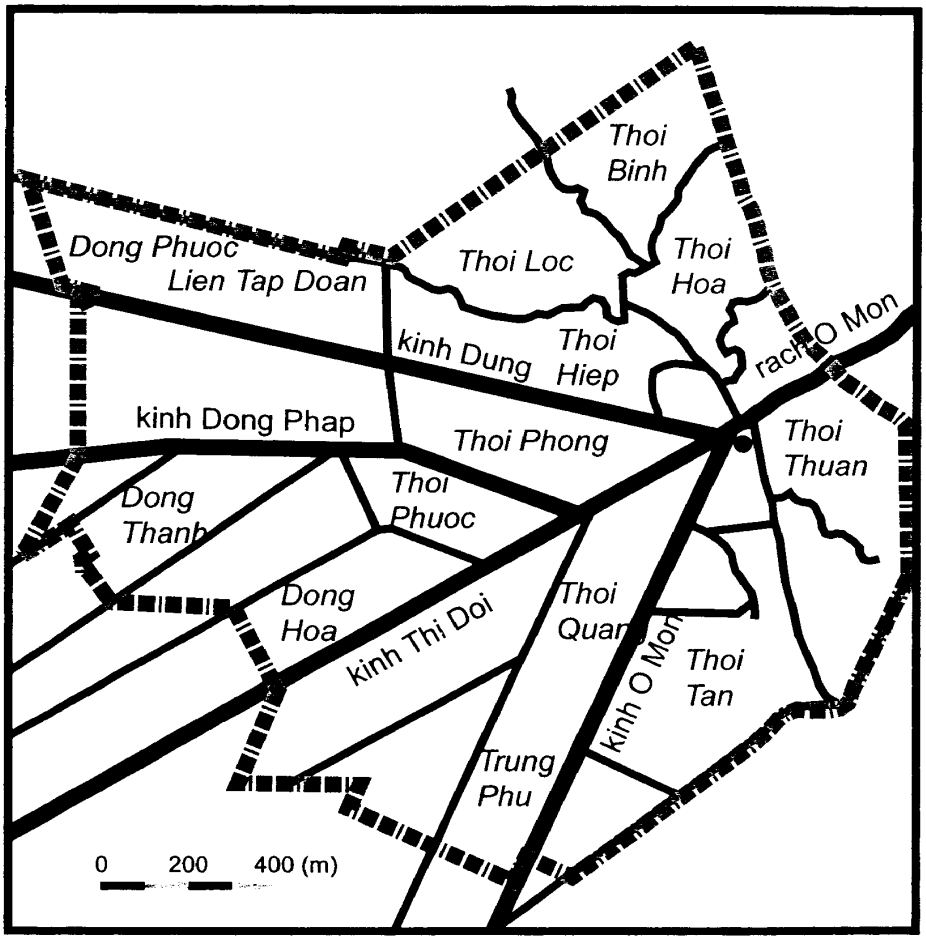

Fig. 3 Thoi Lai Village: Canal Layout and Distribution of the Hamlets

Thoi Thuan and Thoi Tan, are located in the tide-affected floodplain, and the remainders, Dong Phuoc, Lien Tap Doan, Thoi Hiep, Thoi Phong, Thoi Phuoc, Dong Thanh, Dong Hoa, Thoi Quang and Trung Phu, are located in the broad depression. Land use rights have been transferred to the farmers since the beginning of 1980s following the making of a detailed village map based on aerophotos and ground survey. Ninety percent of the total paddy area had been allocated to farmers by 1997.

The total area of the village is about 6,000 ha, of which agricultural land occupies 4,378 ha. Most of this is paddy land, and fruit gardens occupy 10 to 20% of the total agricultural land in the tide-affected floodplain and less than 10% in the broad depression.

Farm size averages 0.8 ha overall in the village. Land tends to be smaller in the tide-affected floodplain than the broad depression. In Thoi Thuan hamlet, located at the center of the village, the average farm size is 0.3 to 0.4 ha, and in Thoi Hoa hamlet, 80% of the agricultural households have 0.5 to 1 ha of agricultural land. These two hamlets are located in the tide-affected floodplain. In contrast, the average farm size in Dong Thanh hamlet, located in the broad depression, is 1.5 ha.

IV Canal Development and Changes in Rice Cultivation

IV−1 *Before 1975*

The first settlers in the village were Khmers, who are said to have settled on natural levees in the tide-affected floodplain. Kinh migrants to the delta were said to reach the village at the beginning of the 19th century, and gradually came to constitute the majority of the village population. In the early 20th century, the French colonial government excavated three canals, Dung, Thi Doi and O Mon. The Dung canal was a renovated natural watercourse. The construction of these canals is thought to have attracted more Kinh migrants and led to the expansion of paddy fields.

Rice cultivation in the early 1960s was as follows. Cultivation started in May when rain came. In the tide-affected floodplain, nursery beds were prepared in the lowest parts of paddy fields, and seeds were broadcast. In the broad depression, land near a canal was selected for nursery bed and irrigated with canal water. The area of nursery beds was about 5% of that of the main fields. After nursery preparation, weeds in paddy fields, such as *co lat, co nang* and *co song chan*, were cut. During this period, water ponded briefly after heavy rainfall, but there was no water in the paddy fields most of the time. In June, one month after broadcasting, when rain fell regularly and soils became soft, seedlings were transplanted to the second nursery bed, which was four times larger than the first one. The second nursery bed was also prepared in the lowest land, where water depth was about 30 cm. In August, all the paddy fields were covered with water. Water depth was usually 30 to 40 cm, but it reached 70 to 80 cm if heavy rainfall continued. Then the second transplanting was carried out using a wooden tool called *noc* [Nguyen Huu Chiem

1994: 351]. Farmers used canal water only for irrigation of the first nursery in the broad depression; otherwise, rice cultivation relied purely on in-situ rainfall.

In the second half of the 1960s, two new technologies were introduced into the village. American-made four-wheel tractors were introduced into Dong Thanh hamlet in about 1965 and Dong Hoa hamlet in 1967, and replaced the buffalo. Several farmers bought a tractor jointly. This changed the planting method from double transplanting to direct seeding. A tractor could plow land even when the soil was dry and hard. Soil was first plowed, then harrowed 10 to 15 days later. These operations were done before rain came. Then dry seeds were broadcast when rain came. Contract plowing was popular at that time. Tractor owners worked even at night in the peak period and could prepare as much as 10 ha of land per day. The price of contract plowing by machine was 20 kg of unhusked rice per *cong*, 0.13 ha. Direct seeding spread particularly into the broad depression in the western part of the village. This indicates that lack of water during the first nursery and too-rapid increase in water depth during the second transplanting were severe problems for farmers there, which promoted mechanization and changes in planting method.

The other new technology was the use of high yielding varieties, which were introduced into the village in 1968 when they were first released in South Vietnam. HYVs were cultivated in parts of the tide-affected floodplain such as Thoi Thuan hamlet, but they did not spread beyond this area. The speed of introduction of HYVs into the village was, not because its soil and water environment were suitable for HYVs cultivation, but because of its proximity to the Cuu Long Rice Research Institute at O Mon, through which the HYVs were released.

IV-2 *Socialist Economy Period*

The Vietnamese war ended and the country was unified in 1975. Villagers who were evacuated during the war returned home, and peaceful daily life resumed in the rural areas of the Mekong Delta. Here I call the decade from 1975 to 1985 "the socialist economy period."

Three issues characterize the period, though it is still rather difficult to get concrete information about everyday life and the local economic system during this period.

First, land ownership moved from people to the government and individual farmers lost legal claim to their farmland until land use rights started to be granted in the early 1980s. Mutual recognition of land ownership was, of course, maintained at the village and hamlet level.

Second, farming was collectivized at the hamlet level. This began in 1980 and continued for from one to several years, although probably not in all hamlets. Farmlands were returned to the mutually recognized previous landowners after collectivized farming was stopped.

Third, farmers had to sell surplus rice to a government agency under the compulsory

rice collection policy. This policy was effective during the period 1975–89, and was enforced particularly strictly during the period 1978–85, when the government controlled rice traders. The government required rice traders to get permission for their business if they handled more than 100 kg of rice, but a rice trader reported that it was almost impossible to get this permission. There was thought to be little rice trading by the private sector during this period. This has been revitalized since 1985 or 1986.

Although the socialist economy period is generally thought to be one of stagnation, rice cultivation techniques and canal systems changed drastically.

All the paddy fields in the village were single-cropped before 1975, though HYVs were introduced in some areas. Double cropping of rice, a combination of winter-spring rice (DX) with rainy season rice or summer-autumn rice (HT), started just after 1975, probably in 1976. This was first introduced in the tide-affected floodplain in such places as Thoi Thuan, Thoi Hoa, Thoi Hiep and Thoi Loc hamlets, then spread to the broad depression. The double cropping areas were, however, limited to fields along natural streams and canals and having good access to water sources. Some fields along the O Mon and Thi Doi canals were double cropped, but single cropping was maintained along the Dung canal, which was shallow and in poor condition. This indicates that substantial expansion of double cropping was impossible without upgrading the canal system.

Upgrading of the canal system proceeded in three phases. First, main canals were rehabilitated. Second, farm-level canals were excavated and farm layout was re-arranged. Third, lateral canals were rehabilitated, widened and newly excavated. The former two phases were mostly carried out during the socialist economy period, and the last phase after 1985.

The main canal network established during the French period was not maintained during the war, with the result that canal banks crumbled and the water became shallow. After 1975, the government gradually dredged the main canals. The O Mon canal was dredged in 1977, though it is not known when others were done.

In 1980, the government dispatched an engineer to Thoi Hoa and Thoi Thuan hamlets. He designed a farm-level canal layout, in which all the paddy fields had direct access to a canal (Fig. 4). Then the villagers constructed the canals according to his design. Landowners gave up land for new canals without compensation. The labor for construction was collected by means of *lao dong xa hoi*, contribution of labor for community projects, which is required of all adult citizens. This procedure was followed by the other hamlets (Fig. 5). Trung Phu hamlet excavated cross-stripe farm-level canals at intervals of 500 meters. These were called *kinh* 500 and were 6 meters wide and 1.5 meters deep. Farm-level canals in Dong Hoa and Dong Thanh hamlets also have cross-stripes, but the intervals were 500 meters and 1,000 meters, and the canals were 4 meters wide. These works started in 1980 and were completed in 1990. They started in the eastern part of the village, the tide-affected flood plain, and shifted to the western part, the broad depression. In most cases, all the construction works were done within

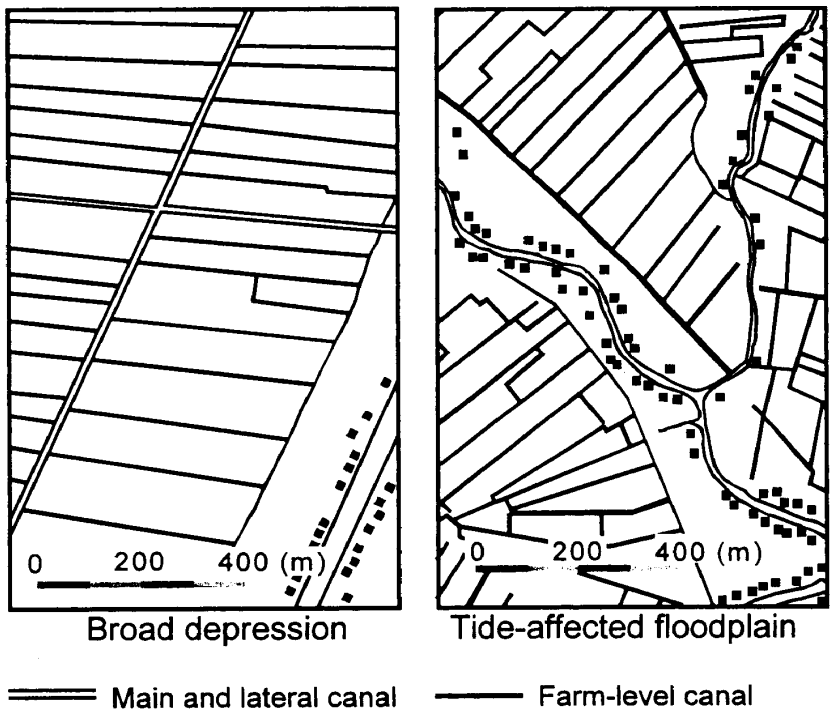

Fig. 4 Farm-level Canal Layout

Source: Prepared from 1 : 5,000 topography map

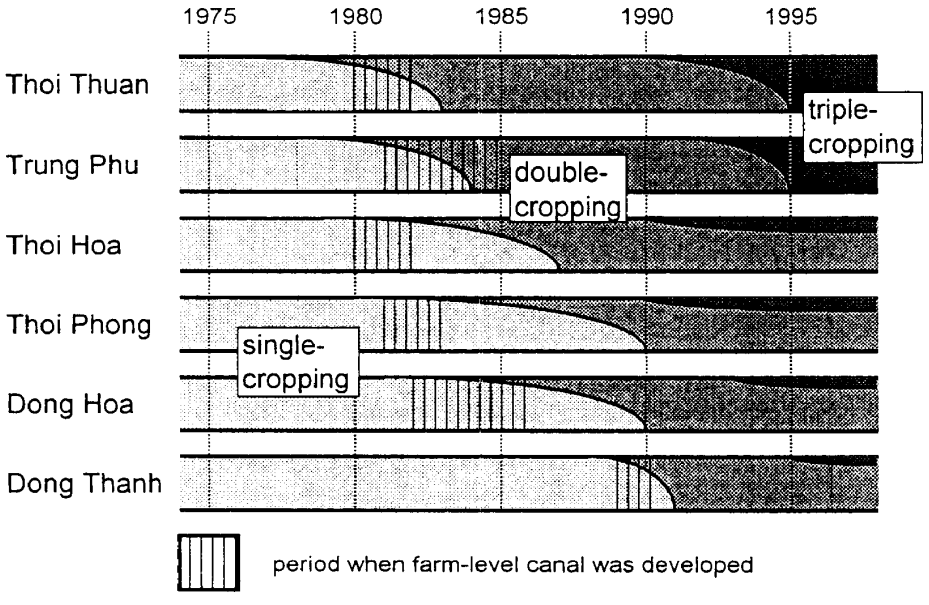

Fig. 5 Changes in Cropping Pattern of Rice Cultivation

one to three years in each hamlet.

These works drastically changed water conditions in the paddy fields. Fresh water is available throughout the year in the canals. Each farmer can irrigate his fields by gravity at times of high tide or by using lifting devices such as diesel pumps. Drainage was also improved. Double cropping of rice expanded rapidly after re-arrangement of the canal layout (Fig. 5).

Ⅳ－3　*After Doi Moi*

Doi moi is a holistic change in economic and social systems introduced in the mid-1980s. Overall changes are from socialist to modified socialist economy and from community-based to household-based economy. In concrete terms, individual farmers were granted land use rights for 20 years. The household was legally recognized as a unit of farming. A market economy was broadly introduced into the trade in rice and other agricultural products as well as agricultural inputs such as chemical fertilizer.

The major changes in rice cultivation since *doi moi* can be summarized in the following three points.

First, lateral canals were upgraded. Farm-level canal networks had been established during the socialist economy period, and double cropping of rice was introduced. But farmers faced water deficits, particularly in areas located far from a main canal. Farm-level canals carried water only at high tide, and farmers along the canal competed to lift water into their own fields. Those who took water first could get enough, but farmers located at the tail of a canal got hardly any water. The local government renovated lateral canals connecting the farm-level canal network with a main canal, and solved the problem.

Second, the input of chemical fertilizer increased. Farmers reported that they nowadays applied 100 to 300 kg of urea, 100 to 200 kg of NPK, a composite of 16–16–8, and 50 to 100 kg of DAP, a composite of 18–46–0, per ha and per crop. This resulted in high yields of paddy, 6 to 7 t/ha of DX and 3.5 to 5 t/ha of HT. These were primarily caused by the economic reforms allowing free sale of surplus rice production and commercialized trading of agricultural input. Improved water conditions through three phases of development provided the fundamental environment for these changes.

Third, cropping intensity is in the process of further intensification from double to triple cropping. At the end of November or the beginning of December when floodwater is falling, farmers pump water from their fields, level the land and broadcast seeds (Fig. 6). Water depth at the time of broadcasting is very shallow, 2 to 3 cm, or there is no surface water. The first rice is harvested in February or March, when the weather is very dry. Rice straw is spread over the fields and burned. The fields are immediately irrigated to a depth of 5 to 20 cm, and seeds are broadcast. One or two days after broadcasting, water is drained and the fields are left dry for several days. Then chemical fertilizer and herbicide are applied, and the fields are irrigated again. A water level of 5 to 10 cm is

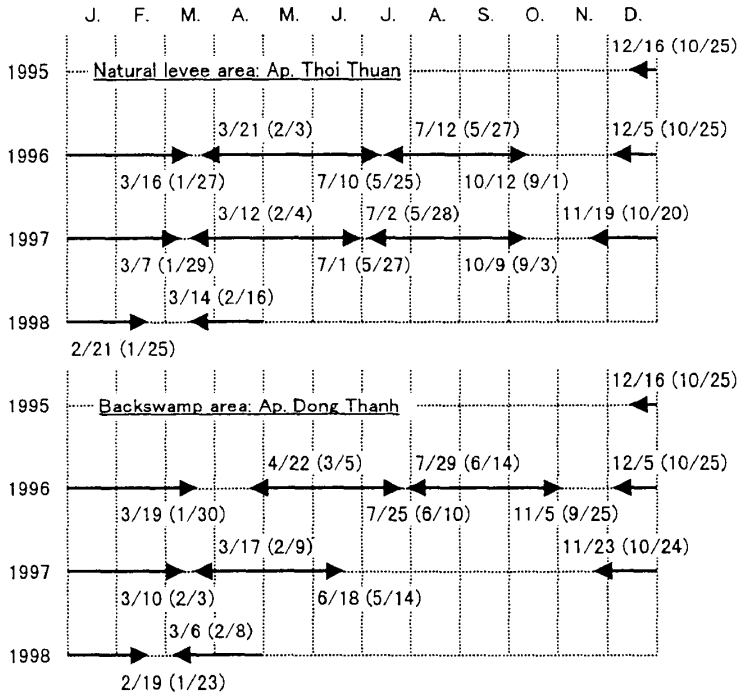

Fig. 6 Examples of Cropping Calendar for Triple Cropping of Rice
Note: Date in parenthesis is lunar calendar date.

maintained until the harvest. This planting method, called *sa chay*, has the advantage that land preparation and planting are quickly done. It requires careful water management in terms of both water depth and timing of irrigation and drainage. The second rice crop is harvested in June or July. This is a crucial time for farmers to decide whether they should grow the third rice crop or not. They consult the seasonal weather forecast and observe the behavior of their neighbors. If they decide to go ahead, they immediately plant the third crop in order to avoid flood damage at harvest time. Examples of cropping calendars clearly show the tight schedule of triple cropping. Farmers recognize the risk of triple cropping and think that the necessary technology is not yet established.

From the viewpoint of water management, two more points should be emphasized. First, portable diesel pumps play a crucial role in the evolution of rice cultivation. In the late 1980s, 1 in 10 or 20 households owned a portable pump. The number of pumps has increased during the last decade. Almost all households own one portable pump in Thoi Hoa, Thoi Binh and Dong Hoa hamlets, and 1 in 5 households own one in Thoi Thuan and Trung Phu hamlets. While the different rates of ownership probably reflect the differences in the ease of gravity irrigation and the need for lifting irrigation, the general popularity of portable pumps indicates that the household is the decision-making body in water management.

The sole exception to individual water management is in drainage for the first rice in triple cropping. The farmers who have fields in the same block surrounded by farm-level canals jointly decide when they will drain water for preparation for the first rice. Then they drain water using their own pumps or pumps borrowed from their neighbors. Drainage begins in the higher fields and shifts to the lower fields. This is the only cooperative water management observed in the village.

V Discussion

V－1 *Interdependency between Canal Development and Intensification of Rice Cultivation*

Until the end of the 1960s, rice cultivation in the Mekong Delta was of low input-low return type in almost totally natural environments. Rice was single-cropped and yields were low. The farm economy largely geared to subsistence, though a small surplus of rice was produced. High yielding rice varieties, reaching the village in 1968, made the first substantial impact toward intensification, but the new technology was hardly accepted by the villagers because water conditions were unsuitable.

During the decade of socialist economy from 1975 to 1985, main canals were rehabilitated and farm-level canals were newly constructed, providing access to water sources for every rice cultivator. All the farmers became capable of managing water conditions in their paddy fields based on their own decisions. Then farmers rushed to introduce HYVs and double cropping. They also applied chemical fertilizers and changed their rice cultivation from low input-low return to high input-high return types.

With the spread of high input-high return cultivation, water shortages arose and farmers competed to get enough water for their own rice cultivation. This problem was particularly visible in the tail parts of the canals. Farmers there irrigated even at night and still could not acquire sufficient water. Increasing the total water supply by renovation of lateral canals solved this problem.

With improved production environment, the farming system is expected to evolve in two directions: triple cropping of rice and crop diversification. Typical crop diversification observed in the study area involves replacing paddy fields by fruit gardens of mandarin and banana. Irrigation is no longer an obstacle; rather, drainage is the key for these developments. The duration of flooding period must be minimized for successful triple cropping, and the peak of flooding must be reduced for successful crop diversification. Farmers started to make efforts to overcome these constraints by themselves. Some farmers have constructed embankments around their land, others drain the land by use of pumps. But their farm-level efforts have a limitation [Kono and Saha 1995]. They can practice the advanced farming in normal years, but not in flood years such as 1996. They have to give up the third rice crop or loose all their fruit trees in such a year.

This process, rapid interaction between infrastructure improvement and technology innovation, accelerated the evolution of paddy-based farming in the Mekong Delta and intensified the cropping system within a short period.

V-2 *Interdependency of Agricultural Development and Institutional Setting*

To examine why the rapid interaction between infrastructure improvement and technology innovation occured, the institutional aspect of agricultural development will be discussed, particularly the impact of institutional setting on the process of agricultural development and the impact of agricultural development on the institutional setting.

The former impact can be particularly observed in the way in which the farm-level canal network could be constructed within a very short time, how the necessary labor was mobilized and the necessary land was provided without compensation.

The simple answer to this question is that, in the socialist economy period, villagers had to follow the instructions of the local authority. *Lao dong xa hoi* was strictly implemented, and farmers lost the legal entitlement of land ownership. Therefore farmers could not reject the government's plan for new canal construction. The social cost of canal construction was relatively low in the socialist economy period.

This view is supported by observations made in a village in Tra Vinh province [Kono and Matsuo 1998]. Tra Vinh province is located in the coastal complex. Rice could not be grown in the dry season due to seawater intrusion and lack of fresh water supply. A new main canal was constructed in this village in 1997, which supplied fresh water to this area even in the dry season. This provided a basic condition for farmers to construct farm-level canal network and change the cropping pattern from single to double cropping. The government dispatched an engineer to the village and ordered the village authority to construct the farm-level canals. This procedure is almost the same as that in Thoi Lai village.

Village leaders were so anxious to construct farm-level canals that they planned to start the construction works at the end of 1996 even before the completion of the main canal construction. They organized meetings with the villagers, particularly with the landholders whose lands were located in the areas of the planned canals. Ten farmers held land for a planned farm-level canal, called N 3 canal. N 3 canal is 1,500 m long and 5 m wide with additional embankments of 5 m wide on both sides, making a total area is 2.2 ha. Each farmer had to provide about 0.2 ha of land. The village leaders spent almost one year in getting their consent. One subject of negotiation was compensation for the land. The village authority offered a price of 3,300,000 *dong/cong*, about 2,540 *dong*/m^2, according to the regulation of the district, but landholders demanded 3,200 *dong*/m^2, which the provincial government paid for the land for the main canal. Another subject was the timing of payment. Funds had to be generated from the farmers who benefited from the canal, so the village authority requested the landholders to wait for the payment until the completion of the construction works and implementation of double cropping,

but landholders insisted on payment in advance. Labor for the construction was mobilized by means of *lao dong xa hoi*, under which men aged between 18 and 45 years old had to work 10 days annually or pay equivalent money. About 70% met their obligation, but the remainder did not. Their excuses were that they were too poor or that they did not benefit from the N 3 canal construction. This information clearly shows the difficulties of local resources mobilization under the *doi moi* policy and relatively low social cost in the socialist economy period.

However, we can not overlook the contribution of the following positive impacts of the farm-level canal construction on its smooth implementation. First, the impact of canal construction was large enough to change the cropping pattern from single to double cropping and to increase rice production drastically. Second, most farmers benefited equally.

Another question is why did farmers rush to adopt double cropping of rice even during the socialist economy period, when the incentive to increase rice production is thought to have been small. One possible answer is as follows. *Doi moi* was initiated in the Mekong Delta. Introduction of market price policy in Long An province in 1985 is said to have been the first step to *doi moi* [Furuta 1996]. Long An province is located at the periphery of the delta, and the land and water conditions are suitable for intensive rice cultivation. Why was *doi moi* initiated in the Mekong Delta in the middle of the 1980s? Increase of rice productivity may be one of the driving forces toward *doi moi*. Farmers' demands for free sale of rice may have led to modification of the socialist economy. Moreover, the chance to sell rice was open equally to all farmers through the individual management of water. This reinforced the farmers' demands to the local authority.

The above explanation involves a kind of irony. While the socialist economy reduced the cost of canal development and consequently provided a chance for all farmers to increase rice production, this achievement led to modification of the socialist economy and the introduction of a market economy.

VI Concluding Remarks

Two interdependencies were pointed out in the present study: one between infrastructure improvement and technical innovation, and the other between agricultural development and institutional setting. These interdependencies have made the Mekong Delta one of the most intensive rice cultivation areas in the world and Vietnam the world's second largest rice exporting country.

Water control and agricultural development in a tropical delta are generally characterized by centralized management. This is also partly true in the Mekong Delta. The broad depression, the plain of reeds and the Long Xuyen quadrangle could not have been

reclaimed without investment from the government. However, the present study clearly shows the active roles of the local community and people. The cooperative works of people, the community and the government, whether intentional or unconscious, supported effective performance of the two interdependent processes.

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